

XII. "On Dredgings and Deep-sea Soundings in the South Atlantic, in a Letter to Admiral RICHARDS, C.B., F.R.S." By Prof. WYVILLE THOMSON, LL.D., F.R.S., Director of the Civilian Staff on board H.M.S. 'Challenger.' Received May 25, 1874.

Melbourne, March 17, 1874.

DEAR ADMIRAL RICHARDS,—I have the pleasure of informing you that, during our voyage from the Cape of Good Hope to Australia, all the necessary observations in matters bearing upon my department have been made most successfully at nineteen principal stations, suitably distributed over the track, and including Marion Island, the neighbourhood of the Crozets, Kerguelen Island, and the Heard group.

After leaving the Cape several dredgings were taken a little to the southward, at depths from 100 to 150 fathoms. Animal life was very abundant; and the result was remarkable in this respect, that the general character of the fauna was very similar to that of the North Atlantic, many of the *species* even being identical with those on the coasts of Great Britain and Norway. The first day's dredging was in 1900 fathoms, 125 miles to the south-westward of Cape Agulhas; it was not very successful.

Marion Island was visited for a few hours, and a considerable collection of plants, including nine flowering species, was made by Mr. Moseley. These, along with collections from Kerguelen Island and from Yong Island, of the Heard group, are sent home with Mr. Moseley's notes, for Dr. Hooker's information.

A shallow-water dredging near Marion Island gave a large number of species, again representing many of the northern types, but with a mixture of southern forms, such as many of the characteristic southern Bryozoa and the curious genus *Serolis* among Crustaceans. Off Prince Edward's Island, the dredge brought up many large and striking specimens of one or two species of Alcyonarian zoophytes, allied to *Mopsea* and *Isis*.

The trawl was put down in 1375 fathoms on the 29th December, and in 1600 fathoms on the 30th, between Prince Edward's Island and the Crozets. The number of species taken in these two hauls was very large; many of them belonged to especially interesting genera, and many were new to science. I may mention that there occurred, with others, the well-known genera *Euplectella*, *Hyalonema*, *Umbellularia*, and *Flabellum*; two entirely new genera of stalked Crinoids belonging to the Apocrinidæ; *Pourtalesia*; several Spatangoids new to science (allied to the extinct genus *Ananchytes*); *Salenia*; several remarkable Crustaceans; and a few fish.

We were unfortunately unable to land on Possession Island on account

of the weather ; but we dredged in 210 fathoms and 550 fathoms, about 18 miles to the S.W. of the island, with a satisfactory result. We reached Kerguelen Island on the 7th of January, and remained there until the 1st of February. During that time Dr. v. Willemöes-Suhm was chiefly occupied in working out the land-fauna, Mr. Moseley collected the plants, Mr. Buchanan made observations on the geology of those parts of the island which we visited, and Mr. Murray and I carried on the shallow-water dredging in the steam-pinnace. Many observations were made, and large collections were stored in the different departments. We detected at Kerguelen Island some peculiarities in the reproduction of several groups of marine invertebrates, and particularly in the Echinodermata, which I have briefly described in a separate paper.

Two days before leaving Kerguelen Island, we trawled off the entrance of Christmas Harbour ; and the trawl-net came up, on one occasion, nearly filled with large cup-sponges belonging to the genus *Rossella* of Carter, and probably the species dredged by Sir James Clark Ross near the ice-barrier, *Rossella antarctica*.

On the 2nd of February we dredged in 150 fathoms, 140 miles south of Kerguelen, and on the 7th of February off Yong Island, in both cases with success.

We reached Corinthian Bay, in Yong Island, on the evening of the 6th, and had made all arrangements for examining it, as far as possible, on the following day ; but, to our great disappointment, a sudden change of weather obliged us to put to sea. Fortunately Mr. Moseley and Mr. Buchanan accompanied Captain Nares on shore for an hour or two on the evening of our arrival, and took the opportunity of collecting the plants and minerals within their reach. A cast of the trawl taken in lat. $60^{\circ} 52' S.$, long. $80^{\circ} 20' S.$, at 1260 fathoms, was not very productive, only a few of the ordinary deep-sea forms having been procured.

Our most southerly station was on the 14th of February, lat. $65^{\circ} 42' S.$, long. $79^{\circ} 49' E.$ The trawl brought up, from a depth of 1675 fathoms, a considerable number of animals, including Sponges, Alcyonarians, Echinids, Bryozoa, and Crustacea, all much of the usual deep-sea character, although some of the species had not been previously observed. On February 26th, in 1975 fathoms, *Umbellularia*, *Holothuriae*, and many examples of several species of the *Ananchytidae* were procured ; and we found very much the same group of forms at 1900 fathoms on the 3rd of March. On the 7th of March, in 1800 fathoms, there were many animal forms, particularly some remarkable starfishes, of a large size, of the genus *Hymenaster* ; and on the 13th of March, at a depth of 2600 fathoms, with a bottom-temperature of $0^{\circ} 2 C.$, *Holothuriae* were abundant, there were several starfishes and *Actiniae*, and a very elegant little Brachiopod occurred attached to peculiar concretions of manganese which came up in numbers in the trawl.

In nine successful dredgings, at depths beyond 1000 fathoms, between the Cape and Australia:—

Sponges were met with on	6 occasions.
Anthozoa Octactinia	7 „
— Polyactinia	6 „
Crinoidea	4 „
Asteroidea	8 „
Ophiuridea	9 „
Echinidea	„
Holothuridea	8 „
Bryozoa	6 „
Tunicata	5 „
Sipunculacea	3 „
Nematodes	1 „
Annelida	8 „
(<i>Myzostomum</i>)	2 „
<i>Balanoglossus</i>	1 „
Cirripedia	4 „
Ostracoda	1 „
Isopoda	7 „
Amphipoda	3 „
Schizopoda	5 „
Decapoda Macrura	6 „
— Brachyura	2 „
Pycnogonida	2 „
Lamellibranchiata	5 „
Brachiopoda	2 „
Gasteropoda	4 „
Cephalopoda	3 „
Teleostei	6 „

It is of course impossible to determine the species with the books of reference at our command; but many of them are new to science, and some are of great interest from their relation to groups supposed to be extinct. This is particularly the case with the Echinodermata, which are here, as in the deep water in the north, a very prominent group.

During the present cruise special attention has been paid to the nature of the bottom, and to any facts which might throw light upon the source of its materials.

This department has been chiefly in the hands of Mr. Murray; and I have pleasure in referring to the constant industry and care which he has devoted to the preparation, examination, and storing of samples. I extract from Mr. Murray's notes:—

“In the soundings about the Agulhas bank, in 100 to 150 fathoms, the bottom was of a greenish colour, and contained many crystalline par-

ticles (some dark-coloured and some clear) of Foraminifera, species of *Orbulina*, *Globigerina*, and *Pulvinulina*, a pretty species of *Uvigerina*, *Planorbulina*, *Miliolina*, *Bulimina*, and *Nummulina*. There were very few Diatoms.

"In the deep soundings and dredgings before reaching the Crozets, in 1900, 1570, and 1375 fathoms, the bottom was composed entirely of *Orbulina*, *Globigerina*, and *Pulvinulina*, the same species which we get on the surface, but all of a white colour and dead. Of Foraminifera, which we have not got on the surface, I noticed one *Rotalia* and one *Polystomella*, both dead. Some Cocoliths and Rhabdoliths were also found in the samples from these soundings. On the whole, these bottoms were, I think, the purest carbonate of lime we have ever obtained. When the soundings were placed in a bottle and shaken up with water, the whole looked like a quantity of sago. The *Pulvinulinae* were smaller than in the dredgings in the Atlantic. We had no soundings between the Crozets and Kerguelen.

"The specimens of the bottom about Kerguelen were all from depths from 120 to 20 fathoms, and consisted usually of dark mud, with an offensive sulphurous smell. Those obtained furthest from land were made up almost entirely of matted sponge-spicules. In these soundings one species of *Rotalia* and one other Foraminifer occurred.

"At 150 fathoms, between Kerguelen and Heard Island, the bottom was composed of basaltic pebbles. The bottom at Heard Island was much the same as at Kerguelen.

"The sample obtained from a depth of 1260 fathoms, south of Heard Island, was quite different from any thing we had previously obtained. It was one mass of Diatoms, of many species; and, mixed with these, a few small *Globigerinae* and Radiolarians, and a very few crystalline particles.

"The soundings and dredgings while we were among the ice in 1675, 1800, 1300, and 1975 fathoms, gave another totally distinct deposit of yellowish clay, with pebbles and small stones, and a considerable admixture of Diatoms, Radiolarians, and *Globigerinae*. The clay and pebbles were evidently a sediment from the melting icebergs, and the Diatoms, Radiolarians, and Foraminifera were from the surface-waters.

"The bottom from 1950 fathoms, on our way to Australia from the Antarctic, was again exactly similar to that obtained in the 1260-fathoms sounding south of Heard Island. The bottom at 1800 fathoms, a little further to the north (lat. 50° 1' S., long. 123° 4' E.), was again pure '*Globigerina*-ooze,' composed of *Orbulinae*, *Globigerinae*, and *Pulvinulinae*.

"The bottom at 2150 fathoms (lat. 47° 25' S., long. 130° 32' E.) was similar to the last, with a reddish tinge; and that at 2600 fathoms (lat. 42° 42' S., long. 134° 10' E.) was reddish clay, the same which we got at like depths in the Atlantic, and contained manganese nodules and much decomposed Foraminifera."

Mr. Murray has been induced, by the observations which have been made in the Atlantic, to combine the use of the towing-net, at various depths from the surface to 150 fathoms, with the examination of the samples from the soundings. And this double work has led him to a conclusion (in which I am now forced entirely to concur, although it is certainly contrary to my former opinion) that the bulk of the material of the bottom in deep water is, in all cases, derived from the surface.

Mr. Murray has demonstrated the presence of *Globigerina*, *Pulvinulina*, and *Orbulina* throughout all the upper layers of the sea over the whole of the area where the bottom consists of "*Globigerina*-ooze" or of the red clay produced by the decomposition of the shells of Foraminifera; and their appearance when living on the surface is so totally different from that of the shells at the bottom, that it is impossible to doubt that the latter, even although they frequently contain organic matter, are all dead. I mean this to refer only to the genera mentioned above, which practically form the ooze. Many other Foraminifera undoubtedly live in comparatively small numbers, along with animals of higher groups, on the bottom.

In the extreme south the conditions were so severe as greatly to interfere with all work. We had no arrangement for heating the work-rooms; and at a temperature which averaged for some days 25° F., the instruments became so cold that it was unpleasant to handle them, and the vapour of the breath condensed and froze at once upon glass and brass work. Dredging at the considerable depths which we found near the Antarctic Circle became a severe and somewhat critical operation, the gear being stiffened and otherwise affected by the cold, and we could not repeat it often.

The evening of the 23rd of February was remarkably fine and calm, and it was arranged to dredge on the following morning. The weather changed somewhat during the night, and the wind rose. Captain Nares was, however, most anxious to carry out our object, and the dredge was put over at 5 A.M. We were surrounded by icebergs, the wind continued to rise, and a thick snow-storm came on from the south-east. After a time of some anxiety the dredge was got in all right; but, to our great disappointment, it was empty,—probably the drift of the ship and the motion had prevented its reaching the bottom. In the mean time the wind had risen to a whole gale (force=10 in the squalls), the thermometer fell to 21°·5 F., the snow drove in a dry blinding cloud of exquisite star-like crystals, which burned the skin as if they had been red-hot, and we were not sorry to be able to retire from the dredging-bridge.

Careful observations on temperature are already in your hands, reported by Captain Nares. The specific gravity of the water has been taken daily by Mr. Buchanan; and, during the trip, Mr. Buchanan has determined the amount of carbonic acid in 24 different samples—15 from the surface,

7 from the bottom, and 2 from intermediate depths. The smallest amount of carbonic acid was found in surface-water on the 27th January, near Kerguelen; it amounted to 0.0373 gramme per litre. The largest amount, 0.0829 gramme per litre, was found in bottom-water on the 14th February, when close to the Artarctic ice. About the same latitude the amount of carbonic acid in surface-water rose to the unusual amount of 0.0656 gramme per litre; in all other latitudes it ranged between 0.044 and 0.054 gramme per litre. From the greater number of these samples the oxygen and nitrogen were extracted, and sealed up in tubes.

The considerations connected with the distribution of temperature and specific gravity in these southern waters are so very complicated, that I prefer postponing any general *résumé* of the results until there has been time for full consideration.

While we were among the ice all possible observations were made on the structure and composition of icebergs. We only regretted greatly that we had no opportunity of watching their birth, or of observing the continuous ice-barrier from which most of them have the appearance of having been detached. The berg- and floe-ice was examined with the microscope, and found to contain the usual Diatoms. Careful drawings of the different forms of icebergs, of the positions which they assume in melting, and of their intimate structure were made by Mr. Wild, and instantaneous photographs of several were taken from the ship.

Upwards of 15,000 observations in meteorology have been recorded during the trip to the south. Most of these have already been tabulated and reduced to curves, and otherwise arranged for reference in considering the questions of climate on which they bear.

Many specimens in natural history have been stored in about seventy packing-cases and casks, containing, besides dried specimens, upwards of 500 store-bottles and jars of specimens in spirit.

I need only further add that, so far as I am able to judge, the expedition is fulfilling the object for which it was sent out. The naval and the civilian staff seem actuated by one wish to do the utmost in their power, and certainly a large amount of material is being accumulated.

The experiences of the last three months have of course been somewhat trying to those of us who were not accustomed to a sea-life; but the health of the whole party has been excellent. There has been so much to do that there has been little time for weariness; and the arrangements continue to work in a pleasant and satisfactory way.

(Signed) CHARLES WYVILLE THOMSON.